

I claim:

1. Fiber optic enhanced scintillator apparatus, comprising a scintillator for producing photons upon being energized by particles, energy or rays, the scintillator further comprising a scintillator body made of scintillator material, surfaces on the body for directing photons toward a photon output, single or multiple light-conducting optical fibers having proximal and distal ends, and proximal ends of the fibers connected to the output for receiving photons from the output.

2. The apparatus of claim 1, further comprising a photon detector connected to the distal end of the single or multiple optical fibers.

3. The apparatus of claim 2, wherein the optical fibers are sufficiently long for controlling dark current related problems.

4. The apparatus of claim 1, wherein the scintillator is configured for use far below an earth surface, wherein the optical fibers extend from the scintillator far below the earth's surface to the detector which is mounted above the earth's surface.

5. The apparatus of claim 1, wherein the scintillator further comprises an optical coupler between the scintillator body and the output.

6. The apparatus of claim 5, wherein the optical coupler further comprises an array of micro lenses for directing photons from the scintillator body toward the output and the proximal end of the single or multiple optical fibers.

7. The apparatus of claim 6, further comprising a second optical coupler connected to the scintillator body remote from the first optical coupler, and a second array of micro lenses in the second optical coupler for directing photons from a second part of the scintillator body to the second output, and further comprising second single or multiple optical fibers connected to the second output.

8. The apparatus of claim 1, wherein the first and second output and a second single or multiple optical fibers have distal ends connected to a single detector.

9. The apparatus of claim 1, wherein the first and second single or multiple optical fibers have distal ends connected to multiple detectors.

10. The apparatus of claim 2, further comprising an electronic cooler connected to the detector.

11. The apparatus of claim 10, further comprising a magnetic field shielding surrounding the detector and the cooler.

12. The apparatus of claim 2, further comprising an electromagnetic field shielding surrounding the detector.

13. The apparatus of claim 1, wherein the scintillator body comprises a truncated conical shape having first and second radiused ends that are convex, concave or flat.

14. The apparatus of claim 13, further comprising first and second micro lens arrays optically coupled to the first and second radiused ends for focusing photons from the scintillator with the micro lenses in the arrays, and further comprising second single or multiple optical fibers connected near the second radiused end of the scintillator body, the second single and multiple optical fibers having a proximal end for receiving photons directed thereto by the micro lenses in the second array.

15. The apparatus of claim 1, further comprising a second output and first and second elastomeric optical coupler bodies connected to the scintillator body at opposite portions thereof for delivering photons from the scintillator body to the outputs, and for cushioning vibrations and impacts encountered by the scintillator.

16. The apparatus of claim 1, wherein the scintillator comprises a scintillator plate with an elastomer layer on one side optically coupled to the scintillator, a gamma ray window connected to the elastomer layer for admitting gamma rays into the scintillator plate, an optical coupler on the scintillator plate opposite the gamma ray window and the elastomer layer, and

optical fibers having proximal ends connected to the optical coupler for conducting photons from the optical coupler through the optical fibers.

17. The apparatus of claim 16, wherein the optical fibers are arranged in optical bundles or cables.

18. The apparatus of claim 16, wherein the optical fibers comprise single or multiple optical fibers.

19. The apparatus of claim 16, further comprising a micro lens array connected to the optical coupler and to the proximal ends of the optical fibers for directing photons from the scintillator to the proximal ends of the optical fibers.

20. The apparatus of claim 16, wherein the scintillator plate is segmented in multiple segments, and the segments of the plate have optical couplers with proximal ends of optical fibers connected to the optical couplers on the segments of the plate, and wherein optical fibers connected to each segment are arranged in bundles for carrying photons from each segment through the optical fiber bundles to distant photon detectors at distal ends of the optical fibers.

21. The apparatus of claim 20, wherein the detectors are surrounded by electronic coolers.

22. The apparatus of claim 21, wherein the detectors are surrounded by magnetic field shielding.

00000000000000000000000000000000

23. The apparatus of claim 1, wherein the scintillator body comprises plural individual scintillator bodies and a holder connected to the scintillator bodies for holding the plural scintillator bodies in an array, and wherein the optical fibers comprise single or multiple optical fibers having proximal ends connected to the plural scintillator bodies.

24. The apparatus of claim 23, further comprising plural micro lenses connected to the plural scintillator bodies for coupling photons from the plural scintillator bodies to the proximal ends of the optical fibers.

25. The apparatus of claim 24, wherein the holder is flexible.

26. The apparatus of claim 24, wherein the holder is resilient.

27. The apparatus of claim 24, wherein the holder is elongated and flexible and the plural scintillator bodies are arranged axially in the holder.

28. The apparatus of claim 23, further comprising optical couplers provided on sides of the plural scintillator bodies for coupling the scintillator bodies to proximal ends of the optical fibers.

29. The apparatus of claim 28, wherein the plural optical bodies have square, polygonal, rectangular, oval or round cross-sections.

00000000

30. The apparatus of claim 23, wherein the plurality of scintillators comprises a plurality of independent scintillators, wherein the independent scintillators are angularly related to an axial direction of the holder, and wherein proximal ends of the optical fibers are connected to lateral edges of the angularly related scintillator bodies.

31. The apparatus of claim 30, wherein the plurality of independent scintillators have square, polygonal, rectangular, oval, round cross-sections, or any other combination thereof.

32. The apparatus of claim 30, wherein the angularly related plural independent scintillators have optical connectors at opposite side edges for connecting to first and second groups of optical fibers at opposite side edges of the plural bodies.

33. The apparatus of claim 30, further comprising bundling the optical fibers connected to the plural bodies, connecting optical fibers at first sides of the plural angularly related independent scintillators to a first fiber optic cable, and connecting optical fibers at opposite sides of the plural angularly related independent scintillators to a second fiber optic cable.

34. Fiber optic enhanced scintillator method, comprising providing a scintillator body made of scintillator material, providing surfaces on the body for directing photons toward a photon output, providing single or multiple light-

conducting optical fibers having proximal and distal ends, connecting proximal ends of the optical fibers to the output for receiving photons from the output, and producing photons upon a scintillator being energized by subatomic particles, energy or rays.

35. The method of claim 34, further comprising connecting a photon detector to the distal ends of the single or multiple optical fibers.

36. The method of claim 35, further comprising providing the optical fibers sufficiently long, and controlling dark current related problems with long optical fibers.

37. The method of claim 34, further comprising configuring the scintillator for use far below an earth's surface, mounting the detector on the earth's surface, extending the optical fibers from the scintillator far below the earth's surface to the detector which is on the earth's surface, and transmitting photons from the scintillator through the optical fibers to the detector.

38. The method of claim 34, further comprising providing an optical coupler between the scintillator body and the output.

39. The method of claim 38, further comprising providing an array of micro lenses on the optical coupler, and directing photons from the scintillator body through the micro

03261474

lenses and toward the output and the proximal ends of the single or multiple optical fibers.

40. The method of claim 39, further comprising providing a second optical coupler, and providing a second photon output on the scintillator body remote from the first optical coupler, and providing a second array of micro lenses on the second optical coupler, directing photons from a second part of the scintillator body to the second output, and providing second single or multiple optical fibers having proximal ends connected to the second output.

41. The method of claim 40, further comprising connecting distal ends of the first and second single or multiple optical fibers to a single detector.

42. The method of claim 40, further comprising connecting distal ends of the first and second single or multiple optical fibers to multiple detectors.

43. The method of claim 35, further comprising connecting an electronic cooler to the detector.

44. The method of claim 43, further comprising surrounding the detector and the cooler with a magnetic field shielding.

45. The method of claim 35, further comprising surrounding the detector with an electromagnetic field shielding.

TOP SECRET//COMINT

46. The method of claim 34, further comprising providing the scintillator body with a truncated conical shape having first and second radiused ends.

47. The method of claim 46, further comprising optically coupling first and second micro lens arrays to the first and second radiused ends, focusing photons from the scintillator with the micro lenses in the arrays, and further comprising providing second single or multiple optical fibers near the second radiused end of the scintillator body, a proximal end of the second single and multiple optical fibers receiving photons directed thereto by the second micro lenses in the second array.

48. The method of claim 34, further comprising providing elastomeric optical coupler bodies and photon outputs on the scintillator body at opposite portions thereof, delivering photons from the scintillator body to outputs, and cushioning vibrations and impacts encountered by the scintillator with the elastomeric optical coupler bodies.

49. The method of claim 34, further comprising providing a scintillator plate, optically coupling an elastomer layer to the scintillator plate, providing a gamma ray window on the elastomer layer, admitting gamma rays into the scintillator plate, providing an optical coupler on the scintillator plate opposite the gamma ray window and the elastomer layer, connecting

proximal ends of optical fibers to the optical coupler, and conducting photons from the scintillator plate through the optical coupler and through the optical fibers.

50. The method of claim 49, further comprising providing the optical fibers as single or multiple optical fibers, and arranging the optical fibers in optical bundles or cables.

51. The method of claim 50, further comprising providing a micro lens array on the optical coupler, mounting the proximal ends of the optical fibers in optical alignment with the micro lenses in the array, and directing photons from the scintillator plate to the proximal ends of the optical fibers.

52. The method of claim 49, wherein the scintillator plate is segmented in multiple segments, connecting proximal ends of the optical fibers to optical couplers on each segment of the plate, arranging optical fibers connected to each segment in bundles, and carrying photons from the plate through the optical fibers to distant photon detectors at distal ends of the optical fibers.

53. The method of claim 52, further comprising contacting the photon detectors with electronic coolers, and transferring heat from the photon detectors to the electronic coolers.

CONFIDENTIAL

54. The method of claim 52, further comprising surrounding the photon detectors with magnetic field shielding.

55. The method of claim 34, further comprising providing plural individual scintillator bodies, providing a holder connected to the scintillator bodies, holding the plural scintillator bodies in an array, and connecting proximal ends of the single or multiple optical fibers to each of the plural individual scintillator bodies.

56. The method of claim 55, further comprising providing plural micro lens arrays on the plural scintillator bodies, and directing photons from the plural scintillator bodies through the plural micro lens arrays to the proximal ends of the optical fibers.

57. The method of claim 56, further comprising providing a flexible and resilient holder.

58. The method of claim 55, further comprising providing an elongated holder and arranging the plural scintillator bodies in an axial array.

59. The method of claim 55, further comprising providing optical couplings on sides of the plural scintillator bodies, and coupling sides of the scintillator bodies to the proximal ends of the optical fibers.

60. The method of claim 59, wherein the plural scintillator bodies are provided with square, polygonal, rectangular, oval or round cross-sections.

61. The method of claim 55, wherein the providing of the plural scintillator bodies comprises providing a plurality of independent scintillators, angularly relating the independent scintillators to each other, and connecting the proximal ends of the optical fibers to lateral edges of the angularly related independent scintillator bodies.

62. The method of claim 61, wherein the plural of scintillator bodies are provided with square, polygonal, rectangular, oval or round cross-sections.

63. The method of claim 61, further comprising providing optical connectors at opposite side edges of the angularly related plural scintillator bodies, and connecting the optical fibers to the optical connectors at the opposite side edges of the plural bodies.

64. The method of claim 61, further comprising bundling the optical fibers connected to the plural scintillator bodies, connecting optical fibers at one end of an array of the plural angularly sloped bodies to a first fiber optic cable, and connecting optical fibers at opposite sides of the array of the plural angularly related scintillator bodies to a second fiber optic cable.

Casefile# : DE2000

65. The method of claim 34, further comprising connecting a detector to the distal ends of the optical fibers and cooling the detector with an electronic cooler surrounding the detector.

66. The method of claim 65, further comprising shielding the detector from magnetic fields by surrounding the detector with magnetic field shielding.

67. Photon scintillator detector apparatus, comprising a scintillator body for producing photons, single or multiple optical fibers connected to the scintillator body, a photon detector having an input and single or multiple optical fibers connected to the input for providing photons to the detector.

68. The apparatus of claim 67, further comprising an electronic cooler connected to the detector for cooling the detector and electromagnetic field shielding surrounding the detector for shielding the detector from electromagnetic fields.

69. The apparatus of claim 67, further comprising an optical coupler connected to the scintillator body and a micro lens optically coupled to optical fibers.

70. The apparatus of claim 67, wherein the scintillator body is coupled to the optical fibers via optical coupling material that services as a light guide.

71. The apparatus of claim 67, further comprising an optical coupler positioned between and connected between the scintillator body and the distal ends of the optical fibers.

72. The apparatus of claim 71, wherein the optical coupler is a media, an elastomer or glue.

73. The apparatus of claim 71, further comprising a second optical coupler connected to the scintillator body remote from the first optical coupler, and first and second arrays of micro lenses connected to the first and second optical couplers for directing photons from first and second parts of the scintillator body to the second output, wherein the optical fibers comprise first optical fibers, and further comprising second single or multiple optical fibers connected to the second output.

74. The apparatus of claim 67, further comprising a preamplifier connected to the distal ends of the optical fibers and a detector connected to the preamplifier.

75. The apparatus of claim 74, further comprising a magnetic field shielding surrounding the detector, the preamplifier and the cooler.

76. The apparatus of claim 74, further comprising an electronic cooler connected to the preamplifier and to the detector.

00000000000000000000000000000000

77. The apparatus of claim 67, wherein the scintillator body comprises one or more crystals, and wherein the distal ends of the one or more optical fibers are connected between the one or more crystals, and further comprising one or more detectors connected to the distal ends of the optical fibers.

78. The apparatus of claim 67, wherein the scintillator comprises plural individually isolated scintillation crystals as individually isolated detectors.

79. The apparatus of claim 78, wherein the crystals are interconnected by an elastomer.

80. The apparatus of claim 78, wherein the crystals/detectors are interconnected by an optically transparent elastomer, and are connected by the elastomer to the optical fibers in a fiber optic cable or fiber optic cable bundle.

81. A detector apparatus comprising a scintillation crystal assembly, optical fibers connected to the crystal assembly, and further comprising an optical viewing portion connected to the optical fibers for allowing an operator to view the assembly and adjacent objects from a distance, the optical viewing portion having a light source at one or both ends and employing micro lenses, lenses, shaped light guides, or other optical components connected to the optical fibers for providing sharp images of the objects being viewed, the viewing portion

providing observation and shape and size measurements or control functions.

82. Scintillation detection and viewing apparatus comprising optical fibers having proximal and distal ends, a scintillator connected to the distal ends, detectors connected to the proximal ends, and light sources and viewers connected to the proximal ends for illuminating objects at the distal ends and viewing images of the objects at the distal ends.

83. The apparatus of claim 82, wherein the scintillation detection and viewing apparatus is a well logging device.

84. The apparatus of claim 82, wherein the scintillation detection and viewing apparatus is a gamma camera device where one remotely views the patient being examined in real time, or the signal is recorded while the gamma ray examination takes place.

85. The apparatus of claim 82, wherein the scintillation detection and viewing apparatus is a remote gamma ray or other high energy ray or particle measuring tool having optical viewing capabilities for using the combined tool, and a weld inspection unit for examining weld quality and visual inspection before, during and after the scintillation detection.

86. The apparatus of claim 82, wherein the scintillation detection and viewing apparatus is a remote gamma

CROSS-REFERENCED PATENTS

ray, X-ray, high energy particle tool having visual inspection used in radioactive storage tanks applications, automotive industry applications, other industrial tools for measurement of high energy rays or particles, or measurements using such high energy rays or particles for structural integrity, density uniformities, and similar applications.

87. The apparatus of claim 82, wherein the scintillation detection and viewing apparatus comprises a combination of light source, X-ray source, X-ray detector for visual inspection.

88. Scintillation apparatus comprising a scintillator plate with an elastomer layer on one side optically coupled to the scintillator plate, a gamma ray window connected to the elastomer layer for admitting gamma rays into the scintillator plate, an optical coupler on the scintillator plate opposite the gamma ray window and the elastomer layer, and optical fibers having proximal ends connected to the optical coupler for conducting photons from the optical coupler through the optical fibers.

89. The apparatus of claim 88, wherein the optical fibers are arranged in optical bundles or cables.

90. The apparatus of claim 88, wherein the optical fibers comprise single or multiple optical fibers.

91. The apparatus of claim 88, further comprising a micro lens array connected to the optical coupler and to the proximal ends of the optical fibers for directing photons from the scintillator to the proximal ends of the optical fibers.

92. The apparatus of claim 88, wherein the scintillator plate is segmented in multiple segments, and the segments of the plate have optical couplers with proximal ends of optical fibers connected to the optical couplers on the segments of the plate, and wherein optical fibers connected to each segment are arranged in bundles for carrying photons from each segment through the optical fiber bundles to distant photon detectors at distal ends of the optical fibers.

93. Scintillator apparatus comprising plural individual scintillator bodies and a holder connected to the scintillator bodies for holding the plural scintillator bodies in an array, and wherein the optical fibers comprise single or multiple optical fibers having proximal ends connected to the plural scintillator bodies.

94. The apparatus of claim 93, further comprising plural micro lenses connected to the plural scintillator bodies for coupling photons from the plural scintillator bodies to the proximal ends of the optical fibers.

95. The apparatus of claim 93, wherein the holder is flexible.

00000000000000000000000000000000

96. The apparatus of claim 93, wherein the holder is resilient.

97. A scintillator photon detector method comprising providing a scintillator body for producing photons, connecting single or multiple optical fibers to the scintillator body, providing a photon detector having an input, connecting the single or multiple optical fibers to the input, and providing photons to the detector through the optical fibers.

98. The method of claim 97, further providing an electronic cooler, connecting the cooler to the detector, cooling the detector, providing an electromagnetic field shielding, surrounding the detector with the shielding, and shielding the detector from electromagnetic fields.

99. The method of claim 97, further comprising providing an optical coupler connecting the optical coupler to the scintillator body, provides a micro lens and optically coupling the micro lens to optical fibers.

100. The method of claim 97 further comprising providing an optical coupling material, coupling the scintillator body to the optical fibers via the optical coupling material and using the optical coupling as a light guide.

101. The method of claim 97, further comprising providing an optical coupler positioned between and connected between the scintillator body and the distal ends of the optical fibers.

102. The method of claim 101, wherein the providing of the optical coupler comprises providing an optical media, an elastomer or glue.

103. The method of claim 101, further comprising providing a second optical coupler connected to the scintillator body remote from the first optical coupler, and providing first and second arrays of micro lenses connected to the first and second optical couplers, and directing photons from first and second parts of the scintillator body to the first and second outputs, wherein providing the optical fibers comprises providing first optical fibers connected to the first output, and further providing second single or multiple optical fibers connected to the second output.

104. The method of claim 97, further comprising providing a preamplifier, connecting the preamplifier to ends of the optical fibers and connecting the preamplifier to the detector.

105. The method of claim 104, further comprising providing a magnetic field shielding and surrounding the detector, and the preamplifier with the shielding.

106. The method of claim 104, further comprising providing an electronic cooler and connecting the cooler to the preamplifier and to the detector.

107. The method of claim 97, wherein the providing the scintillator body comprises providing one or more crystals, and wherein the connecting the optical fibers comprises connecting distal ends of the optical fibers are connected to the one or more crystals, and further comprising providing one or more detectors connected to proximal ends of the optical fibers.

108. The method of claim 97, wherein the providing the scintillator body comprises providing plural individually isolated scintillation crystals as individually isolated detectors.

109. The method of claim 108, further comprising interconnecting the crystals with an elastomer.

110. The method of claim 108, further comprising interconnecting the crystals by an optically transparent elastomer, and connecting the crystals by the elastomer to the optical fibers in a fiber optic cable or fiber optic cable bundle.

111. A detector method comprising providing a scintillation crystal assembly, and further providing an optical viewing portion for allowing an operator to view the assembly and adjacent objects from a distance, providing a light source at one

CROSS-REFERENCED PATENTS

or both ends of the optical viewing portion, and providing micro lenses, lenses, shaped light guides, or other optical components in the optical viewing portion for providing sharp images of the objects being viewed, providing observation and shape and size measurements or control functions in the optical viewing portion.

112. Scintillation detection and viewing method comprising providing optical fibers having proximal and distal ends, providing a scintillator, connecting the scintillator to the proximal ends, providing detectors, connecting the detectors to the distal ends, providing light sources and viewers, connecting the light sources and viewers to the proximal ends, illuminating objects at the distal ends and viewing images of the objects at the distal ends.

113. The method of claim 112, wherein the providing the scintillator, detector and viewing method is a well logging device.

114. The method of claim 102, wherein the scintillation detection and viewing method is a gamma camera device where one remotely views the patient being examined in real time, or the signal is recorded while the gamma ray examination takes place.

115. The method of claim 102, wherein the scintillation detection and viewing method is a remote gamma ray or other high energy ray or particle measuring tool having optical viewing capabilities for using the combined tool, and a weld inspection

unit for examining weld quality and visual inspection before, during and after the scintillation detection.

116. The method of claim 102, wherein the scintillation detection and viewing method is a remote gamma ray, X-ray, high energy particle tool having visual inspection used in radioactive storage tanks applications, automotive industry applications, other industrial tools for measurement of high energy rays or particles, or measurements using such high energy rays or particles for structural integrity, density uniformities, and similar applications.

117. The method of claim 102, wherein the scintillation detection and viewing method comprises providing a combination of light source, X-ray source, X-ray detector for visual inspection.

118. A scintillation method comprising providing a scintillator plate with an elastomer layer on one side optically coupled to the scintillator plate, a gamma ray window connected to the elastomer layer for admitting gamma rays into the scintillator plate, an optical coupler on the scintillator plate opposite the gamma ray window and the elastomer layer, and optical fibers having proximal ends connected to the optical coupler for conducting photons from the optical coupler through the optical fibers.

119. The method of claim 118, wherein the optical fibers are arranged in optical bundles or cables.

120. The method of claim 118, wherein the optical fibers comprise single or multiple optical fibers.

121. The method of claim 118, further comprising providing a micro lens array connected to the optical coupler and to the proximal ends of the optical fibers for directing photons from the scintillator to the proximal ends of the optical fibers.

122. The method of claim 118, wherein the scintillator plate is segmented in multiple segments, and the segments of the plate have optical couplers with proximal ends of optical fibers connected to the optical couplers on the segments of the plate, and wherein optical fibers connected to each segment are arranged in bundles for carrying photons from each segment through the optical fiber bundles to distant photon detectors at distal ends of the optical fibers.

123. A scintillator method comprising providing plural individual scintillator bodies and providing a holder connected to the scintillator bodies for holding the plural scintillator bodies in an array, providing multiple optical fibers and connecting proximal ends of the multiple optical fibers to the plural scintillator bodies.

124. The method of claim 123, further comprising providing plural micro lenses connected to the plural scintillator bodies for coupling photons from the plural scintillator bodies to the proximal ends of the optical fibers.

125. The method of claim 123, wherein the providing of the holder further comprises providing a flexible holder and allowing the scintillator bodies to move with respect to each other.

126. The method of claim 123, wherein the providing of the holder comprises providing a resilient holder and allowing the scintillator bodies to move with respect to each other.

127. The method of claim 123 further comprising providing a light source, connecting the light source to a distal end of at least one of the multiple optical fibers and illuminating the

scintillator bodies and areas around the scintillator bodies.

128. The method of claim 127 further comprising connecting a viewer to a distal end of at least one of the multiple optical fibers and viewing the illuminated scintillator bodies and the areas around the scintillator bodies with the viewer.

129. The method of claim 34 further comprising providing a light source, connecting the light source to a distal end of at least one of the optical fibers and illuminating the scintillator body and areas around the scintillator body.

130. The method of claim 129 further comprising connecting a viewer to a distal end of at least one of the optical fibers

and viewing the illuminated scintillator body and the areas around the scintillator body with the viewer.

131. An inspection method comprising a gamma ray,x-ray or particle source, a gamma ray, x-ray or particle detector scintillator positioned a distance from the source, an optical fiber bundle connected to the array and a cable connected to the optical fiber bundle, a flexible illuminator source positioned with respect to the cable and having a light source or lens on an end near the detector scintillator array for illuminating the object under inspection, an optical receiver lens positioned with respect to the gamma ray,x-ray or particle scintillator detector array and optical fibers connected to the receiver lens and positioned with respect to the cable for providing visual images of the object under inspection for observing and recording positions on the object under inspection .

132. An apparatus for observing and recording visually a patient in connection with a gamma camera comprising a gamma camera assembly having a scintillator and an optical window connected to the scintillator and optical fibers connected to the optical window and a cable for conducting photons from the scintillator and

optical fibers to photo detectors, a light source supplier in position with respect to the cable and the gamma camera and a lens or light source at an end of the supplier for illuminating an object of the gamma camera and optical fibers positioned with respect to the cable and having a lens at an end for receiving visual images of the object and conveying the digital images to an observation or recording device near the photo detectors.